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PREPUPAL WEIGHT AND DEVELOPMENT TIME OF THE ALKALI BEE *NOMIA MELANDERI*

D. F. MAYER, AND E. R. MILICZKY
Department of Entomology,
Washington State University,
Irrigated Agriculture Research & Extension Center,
Prosser, Washington 99350

Abstract.—Eight hundred alkali bee (*Nomia melanderi* Cockerell) prepupae were collected from a nesting site in the fall of 1996. In the spring of 1997, 500 prepupae were randomly selected, weighed, and each was placed in an individual cell and reared to the adult stage. The developmental stage of each individual was recorded daily. Male prepupae were significantly heavier than female prepupae, there were no significant differences between sexes in development time, and no correlation between weight and development time for either sex under laboratory conditions of uniform temperatures.

Key Words:—Insecta, alkali bee, *Nomia melanderi*, prepupae.

Alkali bees (*Nomia melanderi* Cockerell) are valuable pollinators for alfalfa seed production in the Pacific Northwest (Johansen et al. 1982). They occur naturally in limited areas west of the Rocky Mountains. In nature, nesting is confined to places where the soil is sub-irrigated over a hardpan layer which leads to relatively bare alkali spots (Menke 1954). Alkali bees are managed for alfalfa seed pollination where alfalfa growers construct and maintain "bee beds" for these gregarious, soil-nesting, solitary bees (Johansen et al. 1982). Alkali bees overwinter as prepupae and adults emerge from the soil in late spring or early summer depending on temperature and moisture of the soils (Johansen et al. 1978).

Before the alfalfa blooms and prior to bee emergence, an insecticide is generally applied for control of insect pests. All insecticides used for pre-bloom are highly hazardous to alkali bees (Johansen & Mayer 1990). For bee safety, regulations in Walla Walla County, Washington require these to be applied before 23 May. This date is based on an average date of about 10 days before adult emergence. However, if temperatures are cool or warm, first bee emergence may be anywhere from 25 May to 6 June.

Recently, we initiated research to develop a day-degree model for adult alkali bee emergence to provide more accurate timing and flexibility for pre-bloom insecticide applications. As part of the study we conducted laboratory rearing of prepupae. This paper reports our male and female prepupae weight, development times and the relationship between prepupal weight and development time.

METHODS AND MATERIALS

Eight hundred alkali bee prepupae were dug from the Kentch alkali bee bed at Touchet, Walla Walla County, Washington on 10 Sep 1996, placed together in Petri dishes and transported to the laboratory. They were held at 5° C and 40% RH for about 25 weeks in a refrigerator. On 9 Mar 1997, 500 were randomly selected and removed from the refrigerator. Each prepupa was weighed on a Sa-

Table 1. Comparison of alkali bee prepupal weights and development time by sex.

Sex	Weight (g)	Developmental times		
		Prepupa–pupae	Pupae–adult	Total
Male	0.164 ± 0.001a	21.44 ± 0.392a	14.4 ± 0.091a	35.9 ± 0.380a
Female	0.158 ± 0.001b	22.08 ± 0.564a	14.6 ± 0.145a	36.7 ± 0.536a

[a] Means + SEM in the same column with the same letters did not differ significantly ($P > 0.05$, LSD [SAS Institute 1990]).

torius electronic scale. Initial attempts to identify male and female prepupae according to the method of Nielsen & Bohart (1967) were unsuccessful.

In order to keep track of individual bees each prepupa was placed in an individual cell of a plastic grid tray. The bees in the trays were placed in an incubator at 25° C and 100% RH. Bees were observed daily and the number of days till pupa and to adult was recorded for each bee. At emergence adults were identified as male or female and each bee weighed.

A *t*-test ($P \geq 0.05$) was used mean comparison of prepupal weights and development period lengths between sexes. Regression analyses of development period length against prepupal weight were conducted (SAS Institute 1990). Coefficient of determination values are included.

Results

Four hundred and sixty-five bees were successfully reared to the adult stage. The ratio of males to females was 2:1. The average weight of male prepupae was significantly higher than females (Table 1). There were no significant differences in the number of days from prepupa or pupa to adult or total developmental days between males and females (Table 1). Prepupal weight was not a determinant for either sex in the length of development time from prepupa to pupa* ($r^2 = 0.0001$), pupa to adult ($r^2 = 0.0005$) or prepupa to adult ($r^2 = 0.003$). The average weight of adult male alkali bees was 0.77 (range 0.63–0.98) g and the average weight of adult females was 0.81 (range 0.70–0.98) g.

Discussion

The sex ratio of 2:1 fits into the range reported by Johansen et al. (1978) of 1.01:1 to 2.8:1. In a closely related species, *N. triangulifera* Vachal, the sex ratio varies from equality to slightly male-biased (Wcislo 1992).

Frick (1962) reared alkali bees from prepupa to adult at 25° C. He reported an average time to adult of 37 d but did not separate by sex nor give the length of time spent in the pupal stage. He also suggested the optimum range for alkali bee development was 24° to 26.7° C. In our study the average time for both sexes reared at 25° C was 36.3 days.

The development time of males and females was similar in our study. However, alkali bees exhibit protandry with males emerging from the soil several days earlier than females (Bohart & Cross 1955, Stephen 1959, Johansen et al. 1978, Mayer & Lunden 1993). We speculate that males may have a lower temperature threshold than females for the initiation of development and therefore emerge earlier. An alternative hypothesis is that females remain in the natal nest for some time before digging out.

Conclusions

We found significant differences in prepupal weight between male and female alkali bees, no significant differences between sexes in development time from prepupae to adult, and no correlation between prepupal weight and development time to adult for either sex.

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